

## SPECIFICATION

GEAR CASE ASSEMBLY WITH PRESSURE-COMPENSATING  
FUNCTION FOR MARINE PROPULSION MACHINE

## BACKGROUND OF THE INVENTION

## Field of the Invention

[001] The present invention relates to a marine propulsion machine, such as an outboard motor having an outboard internal combustion engine or an outboard/inboard motor having an inboard internal combustion engine and, more particularly, to a gear case assembly with a pressure-compensating function for a marine propulsion machine.

## Description of the Related Art

[002] A gear case forming a lower part of a marine propulsion machine has a gear chamber for housing a bevel gear mechanism for transmitting power from a drive shaft to a propeller shaft. The gear case contains sufficient lubricating oil in the gear chamber to lubricate bearings supporting a drive shaft and members that need lubrication. The gear case is sealed in a liquid-tight fashion to prevent the seepage of water into the gear case.

[003] The gear case is designed such that the gear chamber has the least necessary volume to construct the marine propulsion machine in lightweight construction and to reduce fluid

resistance that acts on the gear case. Therefore, air in spaces extending above the gear chamber in the gear case is compressed to absorb increase in the volume of the lubricating oil due to thermal expansion when the lubricating oil is heated by heat generated by the gear mechanism housed in the gear chamber.

[004] A gear case provided with a pressure-compensating structure disclosed in, for example, JP 53-24098 U for an outboard engine is provided with a bellows of rubber or the like defining an expansion chamber connected to the gear chamber by a small hole, and disposed in an upper part of a gear chamber to limit the rise of pressure in the gear case below an allowable upper limit.

[005] The expansion chamber of the bellows of the pressure-compensating structure disclosed in this reference expands to absorb an increase in the volume of air contained in the gear case so that the pressure in the gear case may not rise beyond the allowable upper limit when air contained in the gear case expands due to heating by heat generated by stirring the lubricating oil by gears rotated at high speeds in the gear chamber of a limited volume when the outboard engine operates.

[006] A space for installing the special bellows defining the expansion chamber cannot be easily secured in a narrow space extending over the gear case.

[007] The special bellows increases component parts and assembling work, and needs additional work for forming the small

hole connecting the expansion chamber of the bellows and the gear chamber, which increases the cost.

[008]

The present invention has been made in view of the foregoing problems and it is therefore an object of the present invention to provide an inexpensive gear case assembly with a pressure-compensating function for a marine propulsion machine, consisting of a reduced number of parts and capable reducing assembling man-hours.

#### SUMMARY OF THE INVENTION

[009]

To achieve the object, the present invention provides a gear case assembly with a pressure-compensating function forming a lower part of a marine propulsion machine, including: a gear case provided with a vertical drive shaft receiving bore in which a drive shaft is supported for rotation, a gear chamber connected to the lower end of the drive shaft receiving bore and containing a bevel gear mechanism for transmitting power from the drive shaft to a propeller shaft, and a forward/backward selector clutch mechanism, a shift rod receiving bore parallel to the drive shaft receiving bore, receiving a shift rod for operating the forward/backward selector clutch mechanism and having an open upper end opening in an upper surface of the gear case, and a connecting hole connecting an upper part of the drive shaft receiving bore and an upper part of the shift rod receiving bore; and a covering member attached to the upper

surface of the gear case so as to cover the open upper end of the shift rod receiving bore, provided with an opening through which the shift rod is passed into the shift rod receiving bore, and having a body part, and a pressure-compensating wall bulging upward from the body part and defining a pressure-compensating chamber.

[010]           The pressure-compensating chamber contains a volume of air sufficient for absorbing a change in the volume of a fluid contained in the gear case due to thermal expansion in a state where the gear chamber has a limited volume to limit the increase of the pressure in the gear chamber below an allowable upper limit.

[011]           A space is utilized effectively for receiving the upward bulging pressure-compensating wall of the covering member covering the open upper end of the shift rod receiving bore to achieve the pressure-compensating function. Thus, the gear case assembly consists of a small number of parts that can be assembled by reduced man-hours and can be manufactured at a low cost.

[012]           Typically, the shift rod is of a type to select a forward drive mode or a backward drive mode when the same is turned. Since the shift rod turns about its axis, the shift rod does not move vertically relative to the covering member, and hence the gap between the shift rod and the covering member can be easily perfectly sealed.

[013]           According to the present invention, the shift rod may be divided into an upper shift rod and a lower shift rod, and an upper end part of the lower shift rod extending through the covering member and projecting upward from the covering member may be coupled with a lower end part of the upper shift rod. Division of the shift rod into the upper and the lower shift rod and the upward projection of the upper end part of the lower shift rod from the covering member facilitate work for assembling the gear case assembly.

[014]           The covering member may have a shift rod support part extending beneath the upper surface of the gear case, and the pressure-compensating wall may lie above the upper surface of the gear case. Thus, the covering member can be formed in compact construction, and the shift rod can be surely supported by the shift rod support part extending beneath the upper surface of the gear case. Thus, the covering member has a function to support the shift rod extending through the opening thereof in addition to a gear chamber sealing function and a pressure-compensating function.

[015]           Preferably, the covering member has an inner cylindrical part that supports the shift rod passed therethrough, and an outer cylindrical part formed integrally with the inner cylindrical part, the inner and the outer cylindrical part are connected by the upward bulging pressure-compensating wall defining the pressure-compensating chamber opening downward.

[016] Preferably, the inner cylindrical part has an upper expanded part, and an annular sealing member fitted on the shift rod is fitted in the upper expanded part of the inner cylindrical part. Thus, the gap between the covering member and the shift rod can be surely sealed in a liquid-tight fashion.

[017] Preferably, the outer cylindrical part is formed in a size that permits the outer cylindrical part to be fitted in an upper part of the shift rod receiving bore, and an O-ring is put in an annular groove formed in the outside surface of the outer cylindrical part. Thus, the gap between the covering member and the side surface of the shift rod receiving bore can be sealed in a liquid-tight fashion.

[018] Desirably, the upper surface of the covering member excluding the upward bulging pressure-compensating wall is flush with the upper end surface of the annular sealing member fitted in the inner cylindrical part of the covering member, and extends to the peripheral edge of the covering member. The covering member may be provided with a pair of upward bulging pressure-compensating walls respectively defining pressure-compensating chambers, and separated from each other by a groove.

[019] Water that flows down along the shift rod does not stay on the covering member because the water is stopped by the sealing member and is drained away through the peripheral edge of the upper surface.

## BRIEF DESCRIPTION OF THE DRAWINGS

[020] Fig. 1 is a side elevation of an outboard engine including a gear case provided with a drive shaft support structure in a preferred embodiment of the present invention;

[021] Fig. 2 is a sectional view of a drive mechanism built in the gear case shown in Fig. 1;

[022] Fig. 3 is a sectional view of the gear case shown in Fig. 1;

[023] Fig. 4 is a top view of the gear case shown in Fig. 3;

[024] Fig. 5 is a rear view of the gear case shown in Fig. 3;

[025] Fig. 6 is a top view of a bearing-fastening member;

[026] Fig. 7 is a sectional view taken on the line VII-VII in Fig. 6;

[027] Fig. 8 is a top view of a covering member;

[028] Fig. 9 is a bottom view of the covering member shown in Fig. 8;

[029] Fig. 10 is a sectional view taken on the line X-X in Fig. 9;

[030] Fig. 11 is a sectional view of an upper essential part of the gear case shown in Fig. 3;

[031] Fig. 12 is a top view of the upper essential part shown in Fig. 11;

[032] Fig. 13 is a rear view of a rear view of a propeller shaft support member;

[033] Fig. 14 is a sectional view taken on the line XIV-XIV in Fig. 13;

[034] Fig. 15 is a rear view of an assembly of the gear case and the propeller shaft support member;

[035] Fig. 16 is a top view of a closing member;

[036] Fig. 17 is a bottom view of the closing member shown in Fig. 16; and

[037] Fig. 18 is a sectional view taken on the line XVIII-XVIII in Fig. 16.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

[038] A preferred embodiment of the present invention will be described with reference to Figs. 1 to 18.

[039] Fig. 1 is a side elevation of an outboard engine 10 relevant to the present invention. The outboard engine 10 is attached to the transom 1 of a boat by a transom clamp 2.

[040] The transom clamp 2 includes a bracket 3 fastened to the transom 1 with bolts, and a swivel case 5 pivotally supported for turning in a vertical plane by a tilt shaft 4 horizontally extended on a front end part of the bracket 3. The swivel case 5 supports a swivel shaft 6 substantially vertically for turning.

[041] The outboard engine 10 has an engine body 10a connected to the swivel shaft 6 by an upper connecting member 7 and a lower connecting member 8. The outboard engine 10 is able to turn in a vertical plane on the tilt shaft 4 and to turn in



a horizontal plane about the axis of the swivel shaft 6. The engine body 10a includes an extension case 14 connected to at least the connecting member 7 (or the connecting member 8), and a mount case 12 connected to the other connecting member 8 (or the connecting member 7). The mount case 12 is combined with the extension case 14.

[042]           An internal combustion engine 11 is fixedly mounted on the mount case 12. The mount case 12 and the extension case 14 are combined to support the internal combustion engine 11 and a drive mechanism. An oil case or the like may be interposed between the mount case 12 and the extension case 14.

[043]           An engine cover 13a covers at least an upper half part of the internal combustion engine 11. The engine body 10a has an under cover 13b covering a lower half part of the internal combustion engine 11. The engine body 10a defines the appearance of the outboard engine 10. A gear case 15 is connected to the lower end of the extension case 14 of the engine body 10a.

[044]           When the boat is stationary or cruising at a low speed, a lower part of the outboard engine 10 below a part around the lower connecting member 8 is a submerged part that submerges in water.

[045]           The internal combustion engine 11 has a substantially vertical crankshaft 20. A drive shaft 21 coupled with the crankshaft 20 extends down through the extension case 14 into

the gear case 15.

[046]           A bevel gear mechanism 22 and a forward/backward selector clutch mechanism 23 are built in the gear case 15. The rotation of the substantially vertical drive shaft 21 is transmitted through the bevel gear mechanism 22 to a substantially horizontal propeller shaft 24 to rotate a screw propeller 25 mounted on the propeller shaft 24.

[047]           An upper shift rod 26 for operating the forward/backward selector clutch mechanism 23 is supported for rotation in front of the drive shaft 21 parallel to the latter. The upper shift rod 26 is extended through the swivel shaft 16 between the mount case 12 and the gear case 15. A lower shift rod 27 coaxially coupled with the upper shift rod 26 is inserted in the gear case 15.

[048]           The gear case 15 of the outboard engine 10 is an aluminum alloy casting. The gear case 15 has a gear housing 18 defining a gear chamber 15a and having the shape of an artillery shell. The upper and the lower part have a streamline shape in a plane. A lower rear part of the gear case 15 is recessed to form a triangular skeg 16.

[049]           Splash guards 17a and an anticavitation plates 17b extends sideways from the opposite side surfaces of an upper part of the gear case 15. The splash guards 17a are above the anticavitation plates 17b.

[050]           The gear housing 18 having the shape of an artillery shell

extends longitudinally in a horizontal plane above the skeg 16 and bulges out sideways. The gear housing 18 has a closed front end having the shape of the head of an artillery shell, and an open rear end.

[051] Referring to Fig. 3, the gear chamber 15a is formed in a front part of the gear housing 18. A drive shaft receiving bore 15b extends upward from the gear chamber 15a. A propeller shaft receiving bore 15c extends between the gear chamber 15a and the open back end of the gear housing 18.

[052] The substantially vertically extending drive shaft receiving bore 15b, the gear chamber 15a joined to the lower end of the drive shaft receiving bore 15b, and the propeller shaft receiving bore 15c extended horizontally backward from the gear chamber 15a form a substantially L-shaped hollow in the gear case 15.

[053] A shift rod receiving bore 15d is formed in front of the drive shaft receiving bore 15b parallel to the drive shaft receiving bore 15b at a short distance from the drive shaft receiving bore 15b. The shift rod receiving bore 15d opens into a recess 15e of a small diameter formed in front of the gear chamber 15a.

[054] A small speed-measuring bore 15f is formed in front of the shift rod receiving bore 15d parallel to the latter in the gear case 15. A lower end part of the speed-measuring bore 15f is bent forward and opens into the space outside the gear

case 15.

[055]

A suction passage 15g through which water is pumped up is formed behind the drive shaft receiving bore 15b so as to extend along the latter. A lower part of the suction passage 15g is connected to suction ports 15g<sub>1</sub> covered with filters 30 as shown in Fig. 2. A longitudinal, flat exhaust passage 15h having an open upper end is formed behind the suction passage 15g. A lower end part of the exhaust passage 15h extends through the upper wall of the gear housing 18.

[056]

Referring to Fig. 4, the respective open upper ends of the drive shaft receiving bore 15b, the shift rod receiving bore 15d, the speed-measuring bore 15f, the suction passage 15g and the exhaust passage 14h open in the joining surface 19 represented by an area shaded with dots in Fig. 4, i.e., the upper end surface joined to the extension case 14, of the gear case 15. The open upper end of the drive shaft receiving bore 15b sinks slightly beneath the joining surface 19. The gear housing 18 of the gear case 15 has the open rear end.

[057]

Referring to Fig. 3, the drive shaft receiving bore 15b receiving the drive shaft 21 has an upper end part 15b<sub>1</sub> of the largest diameter, an internally threaded part 15b<sub>2</sub> extending down from the upper end part 15b<sub>1</sub> and provided with an internal thread having a major diameter substantially equal to the diameter of the upper end part 15b<sub>1</sub>, and a bearing part 15b<sub>3</sub> extending down from the internally threaded part 15b<sub>2</sub> and having

a diameter substantially equal to the minor diameter of the internal thread of the internally threaded part 15b<sub>2</sub>.

[058] An intermediate part 15b<sub>5</sub> of a medium diameter extends downward from the bearing part 15b<sub>3</sub> so as to form a shoulder 15b<sub>4</sub> at the lower end of the bearing part 15b<sub>3</sub>. A reduced oil-pumping part 15b<sub>6</sub> extends downward from the intermediate part 15b<sub>5</sub>, a reduced part 15b<sub>7</sub> extends down from the oil-pumping part 15b<sub>6</sub>, and a slightly expanded bearing part 15b<sub>8</sub> of a diameter greater than that of the reduced part 15b<sub>7</sub> extends down from the reduced part 15b<sub>7</sub> and opens into the gear chamber 15a.

[059] A connecting hole 15i extends obliquely downward from a lower front part of the upper end part 15b<sub>1</sub> having the largest diameter into the shift rod receiving bore 15d to connect respective upper parts of the drive shaft receiving bore 15b and the shift rod receiving bore 15d.

[060] A suction oil passage 15j extends obliquely downward from a lower front part of the oil-pumping part 15b<sub>6</sub> opens into the gear chamber 15a to connect a lower part of the drive shaft receiving bore 15b and the gear chamber 15a.

[061] The drive shaft 21 is inserted through the upper end of the drive shaft receiving bore 15b in the latter. A taper roller bearing 31 is fitted in the front reduced part of the gear chamber 15a and a forward driven gear 32, i.e., a bevel gear, is supported in the taper roller bearing 31 before inserting the drive shaft 21 in the drive shaft receiving bore 15b.

[062]           A needle bearing 33 is fitted in the lowermost bearing part 15b<sub>8</sub> from below before inserting the drive shaft 21 in the drive shaft receiving bore 15b through the open upper end of the latter.

[063]           A lower end part of the drive shaft 21 extends through the needle bearing 33 into the gear chamber 15a. A drive gear 34, i.e., a bevel gear, is mounted on the lower end part of the drive shaft 21 extended in the gear chamber 15a so as to engage with the forward driven gear 32. A nut 35 is screwed on an externally threaded lower end part of the drive shaft 21 to fasten the drive gear 34 to the drive shaft 21.

[064]           An oil-pumping member 36 provided with an external thread is put on a middle part of the drive shaft 21 corresponding to the oil-pumping part 15b<sub>6</sub> of the drive shaft receiving bore 15b.

[065]           Referring to Fig. 11, two (for example) taper roller bearings 37 are fitted in the bearing part 15b<sub>3</sub> to support the drive shaft 21. An externally threaded bearing-fastening ring 38 (Fig. 3) is screwed in the internally threaded part 15b<sub>3</sub> to fasten the taper roller bearings 37 in place in the bearing part 15b<sub>3</sub>.

[066]           As shown in Figs. 6 and 7, the bearing fastening ring 38 has an outside circumference provided with an external thread 38a, a stellate inside surface with which a tool engages, and a downward annular skirt 38c.

[067]           When the bearing fastening ring 38 is screwed in the internally threaded part 15b<sub>2</sub> of the drive shaft receiving bore 15B, the annular skirt 38c comes into contact with the outer ring of the upper taper roller bearing 37 fitted in the bearing parts 15b<sub>3</sub> to press the outer ring of the lower taper roller bearing 37 against the shoulder 15b<sub>4</sub>, so that the taper roller bearings 37 are held firmly in place in the bearing part 15b<sub>3</sub>.

[068]           Thus, the drive shaft 21 inserted in the drive shaft receiving bore 15b is supported for rotation in the needle bearing 33 and the taper roller bearings 37 on the gear case 15, and is restrained from vertical movement by the taper roller bearings 37 fixedly held in place.

[069]           Referring to Fig. 11, a covering member 40 is fitted in the upper end part 15b<sub>1</sub> to close the open upper end of the drive shaft receiving bore 15b. As shown in Fig. 8 to 10, the covering member 40 has a body part 40a having the shape of a disk and provided with a central circular hole, an upper cylindrical part 40d projecting upward from the body part 40a and surrounding the circular hole of the body part 40a, an inner cylindrical part 40b projecting downward from the body part 40a, and an outer cylindrical part 40c projecting downward from the body part 40a, coaxial with the inner cylindrical part 40b and surrounding the inner cylindrical part 40b.

[070]           The body part 40a has a flange 40a<sub>1</sub> of a diameter slightly greater than the outside diameter of the outer cylindrical part

40c. The inner cylindrical part 40b has an outside diameter greater than that of the upper cylindrical part 40d. The body part 40a is provided with diametrically opposite bosses 40e respectively provided with bolt holes 40e<sub>1</sub> on its periphery.

[071] An annular groove 40c<sub>1</sub> is formed in the outside circumference of the outer cylindrical part 40c. An oil passage 40c<sub>2</sub> is formed in the lower edge of the outer cylindrical part 40c at a predetermined position. A drain hole 40d<sub>1</sub> is formed in a lower front part of the upper cylindrical part 40d.

[072] Referring to Fig. 11, a sealing member 41 is fitted in the inner cylindrical part 40b of the covering member 40, and an O-ring 42 is fitted in the annular groove 40c<sub>1</sub> of the outer cylindrical part 40c. Then, the covering member 40 is fitted in the upper end part 15b<sub>1</sub> of the drive shaft receiving bore 15b to close the open upper end of the drive shaft receiving bore 15b.

[073] The outer cylindrical part 40c of the covering member 40 is fitted in the upper end part 15b<sub>1</sub> and the O-ring 42 seals the gap between the side surface of the drive shaft receiving bore 15b and the outer cylindrical part 40c. The sealing member 41 seals the gap between the drive shaft 21 extending through the central hole of the covering member 40 and the covering member 40. Water seeped along the drive shaft 21 inside the upper cylindrical part 40d is stopped by the sealing member 41 and is drained forward through the drain hole 40d<sub>1</sub>.



[074]           The flange 40a<sub>1</sub> of the covering member 40 is seated on an upper end surface of the gear case 15 around the open upper end of the drive shaft receiving bore 15b with the bosses 40e aligned with internally threaded bosses 15k (Fig. 4) protruding from the upper end surface around the open upper end of the drive shaft receiving bore 15b. Then, two bolts 43 passed through the bolt holes 40e<sub>1</sub> of the bosses 40e are screwed in the internally threaded holes of the bosses 15k to fasten the covering member 40 to the upper end surface around the open upper end of the drive shaft receiving bore 15b of the gear case 15.

[075]           Referring again to Fig. 11, the lower end of the covering member 40 as attached to the gear case 15 is spaced from the upper end of the bearing fastening ring 38 to define a space between the covering member 40 and the bearing fastening ring 38. The connecting hole 15i opens into this space. Thus, the oil passage 40c<sub>2</sub> is positioned such that the connecting hole 15i is not even partly closed even if the covering member 40 is disposed at the lowest possible position to position the forward extending wall 14a of the extension case 14 at a level below the lower end of the swivel shaft 6.

[076]           Thus, the open upper end of the drive shaft receiving bore 15b is covered with the covering member 40, and the taper roller bearings 37 supporting the drive shaft 21 for rotation are held fixedly in place by the bearing fastening ring 38.

[077]            Since the covering member 40 does not need to fasten the taper roller bearings 37, the covering member 40 can be sufficiently firmly fastened to the gear case 15 with the two bolts 43, the gear case 15 needs to be provided with only the two internally threaded bosses 15k around the drive shaft receiving bore 15b to avoid increasing the dimensions of the gear case 15. Increase in the width of the gear case 15, in particular, increases fluid resistance that acts on the moving gear case 15. Therefore, it is desired that the gear case 15 is formed in the narrowest possible width. The bearing fastening member 38 fixes the taper roller bearings 37 firmly to ensure that the drive shaft 21 is prevented from vertical movement.

[078]            As shown in Fig. 11, an under panel 46 is joined to the closed joining surface 19 surrounding the open upper ends of the drive shaft receiving bore 15b and the suction passage 15g with the drive shaft 21 extending through a hole formed in the under panel 46. A water pump 45 is mounted on the under panel 46. The water pump 45 is a displacement water pump driven by the drive shaft 21, The water pump 45 has a pump case 47 located by a locator pin 48 and fixedly joined to the joining surface 19 of the gear case with the under panel 46 held between the pump case 47 and the joining surface 19. An impeller included in the water pump 45 is formed by attaching a plurality of radial blades 45b to the drive shaft 21. The drive shaft 21 is eccentric

with respect to a rotor chamber 45a defined by the pump case 47.

[079]           The pump case 47 has a cylindrical part 47a defining the rotor chamber 45a, an upwardly extending, vertical discharge pipe 47b adjacent to the cylindrical part 47a, and a rectangular flange 47c having a shape corresponding to that of the under panel 46 and extending around the cylindrical part 47a and the discharge pipe 47b as shown in Fig. 12. Bolts 49 are passed through holes formed in the four corners of the flange 47c and are screwed in threaded holes formed in the joining surface 19 of the gear case 15 with washers held between the heads of the bolts 49 and the flange 47c to fasten the pump case 47 to the gear case 15.

[080]           A water passage, not shown, connects the suction passage 15g of the gear case 15 to the rotor chamber 45a. The rotor chamber 45a communicates with the discharge pipe 47b by means of a discharge port 45c formed in a lower part of a wall separating the rotor chamber 45a and the discharge pipe 47b from each other.

[081]           When the water pump 45 is driven by the drive shaft 21, water is sucked through the suction ports 15g<sub>1</sub> formed in the side wall of the gear case 15 and covered with the filters 30, and the suction passage 15g into the rotor chamber 45a.

[082]           Water discharged through from the rotor chamber 45a through the discharge port 45c flows through a water tube connected to the discharge pipe 47b into the internal combustion

engine 11 to cool the internal combustion engine 11.

[083]           The propeller shaft 24 is inserted in the propeller shaft receiving bore 15c. An assembly of the propeller shaft 24, a propeller shaft support member 50 rotatably supporting the propeller shaft 24, part of the bevel gear mechanism 22 and the forward/backward selector clutch mechanism 23 is inserted in the propeller shaft receiving bore 15c.

[084]           The propeller shaft 24 has a propulsion transmission flange 24a in its part nearer to the front end thereof relative to a middle part thereof, and a front cylindrical part 24b provided with a round bore extending from the front end surface thereof to a position near the flange 24a. A slot 24c having a big axial length is formed across the axis of the front cylindrical part 24b in a middle part of the front cylindrical part 24b.

[085]           The propeller shaft support member 50 supports a middle part of the propeller shaft 24. As shown in Figs. 2, 13 and 14, the propeller shaft support member 50 has an expanded front part 51 of a large diameter, an expanded back part 54 of a large diameter, a reduced middle part 53 of a small diameter, and a tapered part connecting the middle part and the front part 51.

[086]           Referring to Fig. 14, the back part 54 has an inner cylindrical part 54a, an outer cylindrical part 54b coaxial with the inner cylindrical part 54a, four radial arms 54c

extending between the inner cylindrical part 54a and the outer cylindrical part 54b. The four arms 54c define exhaust openings 54d.

[087]           A back flange 55 extends around the outer cylindrical part 54b. Attaching bosses 56 respectively provided with bolt holes 56a protrude radially outward from diametrically opposite parts of the back flange 55. Back end parts of the bolt holes 56a are counterbored to form counterbores 56b.

[088]           The depth of the counterbores 56b is slightly greater than the thickness of the head of bolts 71 that fasten the back flange 55 to the gear case 15. When the bolts 71 are passed forward through the bolt holes 56a of the attaching bosses 56 and screwed in threaded holes 18c formed in the gear case 15, the heads of the bolts 71 sink entirely in the counterbores 56b.

[089]           The propeller shaft 24 is inserted through the front end of the propeller shaft support member 50 in the latter with a thrust bearing 60 held between the flange 24a of the propeller shaft 24 and a shoulder formed in the bore of the propeller shaft support member 50, and a needle bearing 61 and a sealing member 62 are put on the propeller shaft 24 as shown in Fig. 2. A ball bearing 63 is fitted in the front part of the propeller shaft support member 50, and the cylindrical boss of a backward driven gear 64, i.e., a bevel gear, is fitted in the inner ring of the ball bearing 63.

[090]           The backward driven gear 64 is spaced from the propeller shaft 24. The propeller shaft 24 and the backward driven gear 64 are supported on the propeller shaft support member 50 for individual rotation.

[091]           A shift slider has a front shift slider 65 and a back shift slider 66 coaxially connected to the front shift slider 65. The back shift slider 66 is axially slidably inserted in the front cylindrical part 24b of the propeller shaft 24. A cylindrical drive-mode selecting member 67 is axially slidably mounted on the front cylindrical part 24b.

[092]           The front shift slider 65 is integrally provided with a pair of flanges 65a and 65b in its back part. The back shift slider 66 has a hollow, round, tubular part having a round bore extending from the front end thereof to a position near the back end thereof. The front shift slider 65 has a reduced back part fitted in a front part of the round bore of the back shift slider 66. A pin is passed across the axis of the propeller shaft 24 through the hollow, round, tubular part of the back shift slider 66 and the reduced back part of the front shift slider 65 fitted in the front part of the back shift slider 66 to couple the front shift slider 65 and the back shift slider 66. Thus, the slider is formed of a small number of parts to reduce cost.

[093]           The hollow, round, tubular part of the back shift slider 66 having an open front end facilitate building a detent

mechanism using a compression spring in the hollow, round, tubular part. A clutch shifter pin 68 is passed through a back part of the back shift slider 66 perpendicularly to the axis of the back shift slider 66. The clutch shifter pin 68 extends through the slot 24c formed in the front cylindrical part 24b of the propeller shaft 24 into a round hole formed in the drive-mode selecting member 67.

[094]           The front shift slider 65 and the back shift slider 66 are moved simultaneously axially to shift the drive-mode selecting member 67 with the clutch shifter pin 68 in a range corresponding to the axial length of the slot 24c.

[095]           The assembly of the propeller shaft 24, the propeller shaft support member 50 rotatably supporting the propeller shaft 24, the back ward driven gear 64 of the bevel gear mechanism 22, and the forward/backward selector clutch mechanism 23 is inserted in the propeller shaft receiving bore 15c.

[096]           The respective outside diameters of the expanded front part 51 and the expanded back part 54 of the propeller shaft support member 50 are substantially equal to the diameter of the propeller shaft receiving bore 15c. An O-ring is put on the front part 51 of the propeller shaft support member 50 before inserting the propeller shaft support member 50 in the propeller shaft receiving bore 15c.

[097]           A front end part of the front cylindrical part 24b of the propeller shaft 24 is fitted in the needle bearing 70 fitted

beforehand in the boss of the forward driven gear 32 inserted previously in the bottom of the gear chamber 15a. A front part of the front shift slider 65 projecting forward from the cylindrical part 24b is received axially slidably and rotatably in a cylindrical hole 15e<sub>1</sub> formed in the bottom of the recess 15e.

[098]           The shift slider consisting of the front shift slider 65 and the back shift slider 66 is supported axially slidably and rotatably for a reliable shifting action.

[099]           The backward driven gear 64 is engaged with the drive gear 34 mounted on the lower end part of the drive shaft 21 to form the bevel gear mechanism 22 in the gear chamber 15a.

[100]           The drive gear 34 rotates together with the drive shaft 21. The drive shaft 21 drives the forward driven gear 32 for rotation in the normal direction, and drives the backward driven gear 64 for rotation in the reverse direction.

[101]           The drive-mode selecting member 67 is disposed axially slidably between the forward driven gear 32 and the backward drive gear 64 to form the forward/backward selector clutch mechanism 23. The drive-mode selecting member 67 is provided on its opposite end surfaces with teeth, and the forward drive gear 32 and the backward driven gear 32 are provided on their end surfaces facing the drive-mode selecting member 67 with teeth that are able to engage with the teeth of the drive-mode selecting member.



[102]           The forward/backward selector clutch mechanism 23 is in a neutral state when the drive-mode selecting member 67 is engaged with neither the forward driven gear 32 nor the backward driven gear 64.

[103]           When the drive-mode selecting member 67 is shifted forward and engaged with the forward driven gear 32, the rotation in the normal direction of the forward driven gear 32 is transmitted through the drive-mode selecting member 67 and the clutch shifter pin 68 to the propeller shaft 24 to rotate the propeller shaft 24 in the normal direction, and thereby the boat is propelled forward.

[104]           When the drive-mode selecting member 67 is shifted backward and engaged with the backward driven gear 64, the rotation in the reverse direction of the backward driven gear 32 is transmitted through the drive-mode selecting member 67 and the clutch shifter pin 68 to the propeller shaft 24 to rotate the propeller shaft 24 in the reverse direction, and thereby the boat is propelled backward.

[105]           When the propeller shaft support member 50 supporting the propeller shaft 24 is inserted in the propeller shaft receiving bore 15c, the back flange 55 formed at the back end of the back part 54 of the propeller shaft support member 50 comes into close contact with the back end surface 18a (an area shaded with dots in Fig. 5), in which the propeller shaft receiving bore 15c opens, of the gear case 15.

[106] In this state, the attaching bosses 56 radially protruding from the back flange 55 are seated on the joining surfaces 18b of bosses provided with bolt holes 18c and extending upward and downward, respectively, from the back end surface 18a in which the propeller shaft receiving bore 15c opens (Figs. 3 and 5). The bosses 56 are respectively provided with bolt holes 56a protrude radially outward from diametrically opposite parts of the back flange 55. The bolts 71 are passed through the bolt holes 56a of the attaching bosses 56 and screwed in the threaded holes 18c formed in the gear case 15 to fasten the propeller shaft support member 50 to the gear case 15.

[107] When the propeller shaft support member 50 inserted in the propeller shaft receiving bore 15c is thus fastened to the gear case 15, the exhaust passages 15h of the gear case 15 communicate with a substantially annular space around the reduced middle part 53 of the propeller shaft support member 50, and the substantially annular space communicates with the exhaust openings 54d of the back part 54. Thus, the exhaust passages 15h communicate with the exhaust openings 54d.

[108] The screw propeller 25 is mounted on a back part, projecting backward from the propeller shaft support member 50, of the propeller shaft 24.

[109] As shown in Fig. 2, the screw propeller 25 has a cylindrical hub 25a, and blades 25b mounted on the hub 25a. A rubber bush 25c is fitted in the cylindrical hub 25a, and the cylindrical

hub 25a is mounted on the back part of the propeller shaft 24.

[110] As mentioned above, the heads of the bolts 71 sink entirely in the counterbores 56b formed in the attaching bosses 56 when the bolts 71 are passed through the bolt holes 56a of the attaching bosses 56 and screwed in the threaded holes 18c formed in the gear case 15. Therefore, separate members for concealing the heads of the bolts 71 are not required so that the total number of parts is reduced and good outer appearance of the bolt heads is obtained.

[111] The parts to be fastened by the bolts 71 are the attaching bosses 56 that radially outwardly protrude from the back flange 55, and the heads of the bolts 71 are sunk in the counterbores 56b, respectively. Therefore, the cylindrical hub 25a of the screw propeller 25 does not need to be extended radially to the positions of the attaching bosses 56 such that the cylindrical hub 25a conceals the heads of the bolts 71, and the cylindrical hub 25a may be formed in a small diameter as shown in Fig. 2 to reduce fluid resistance that acts on the cylindrical hub 25a.

[112] The lower shift rod 27 is inserted in the shift rod receiving bore 15d formed parallel to the drive shaft receiving bore 15b (substantially vertically) in front of the drive shaft receiving bore 15b. As shown in Fig. 3, the shift rod receiving bore 15d has an expanded top part 15d<sub>1</sub> having the largest diameter and opening in the joining surface 19, and a reduced bottom

part 15d<sub>2</sub> opening into the recess 15e.

[113]           A bearing holder 29 rotatably supports a lower part of the lower shift rod 27. A shift fork 28 eccentric to the lower shift rod 27 projects downward from the lower end of the lower shift rod 27.

[114]           When the lower shift rod 27 is inserted in the shift rod receiving bore 15d, the bearing holder 29 is seated on a shoulder at the open upper end of the bottom part 15d<sub>2</sub> of the shift rod receiving bore 15d, the lower part of the lower shift rod 27 extends through the bottom part 15d<sub>2</sub>, and the eccentric shift fork 28 engages in the groove between the pair of flanges 65a and 65b of the front shift slider 65.

[115]           An upper part of the lower shift rod 27 extends upward through and supported for rotation by a covering member 80 closing the shift rod receiving bore 15d. As shown in Figs. 16 to 18, the covering member 80 has a inner cylindrical part 80a, a flat outer cylindrical part 80b, radial ribs 80c connecting the inner cylindrical part 80a and the outer cylindrical part 80b, and a upper wall 80d covering an annular space between the inner cylindrical part 80a and the outer cylindrical part 80b.

[116]           Diametrically opposite parts of the upper wall 80d bulge upward to form a right bulged wall 81R and a left bulged wall 81L. The bulged walls 81R and 81L define pressure-compensating air chambers 82R and 82L. A longitudinal groove 83 is formed

between the bulged walls 81R and 81L. The vertical bore of the inner cylindrical part 80a opens into a middle part of the groove 83.

[117] The respective outside surfaces of the bulged walls 81R and 81L are included in the same cylindrical plane and are separated by the groove 83.

[118] An upper part of the round bore of the inner cylindrical part 80a is expanded to form an expanded end part 80a<sub>1</sub>. A sealing member 85 is fitted in the expanded end part 80 80a<sub>1</sub> as shown in Fig. 11. The outer cylindrical part 80b protrude from the outside surfaces of the bulged walls 81R and 81L. An annular groove 80b<sub>1</sub> is formed in the outside surface of the outer cylindrical part 80b, and an O-ring 86 is fitted in the annular groove 80b<sub>1</sub>.

[119] The covering member 80 is fitted in the open upper end of the shift rod receiving bore 15d to close the latter. As shown in Fig. 11, the outer cylindrical part 80b of the covering member 80 is fitted in the top part 15d<sub>1</sub> of the shift rod receiving bore 15d. The O-ring 86 seals the gap between the outer cylindrical part 80b and the side surface of the top part 15d<sub>1</sub> of the shift rod receiving bore 15d, and the sealing member 85 seals the gap between the lower shift rod 27 and the inner cylindrical part 80a of the covering member 80.

[120] A spring 88 is extended between the lower end of the inner cylindrical part 80a of the covering member 80, and a snap ring

87 put in an annular groove formed in a part of the lower shift rod 27 to press the lower shift rod 27 downward so that the lower shift rod 27 may not shake.

[121]           The outer cylindrical part 80b protruding from the cylindrical plane including the outside surfaces of the bulged walls 81R and 81L of the covering member 80 sinks completely in the top part 15d<sub>1</sub> of the shift rod receiving bore 15d. The under panel 46 on which the water pump 45 is mounted and an end part of the pump case 47 are pressed against the upper surface of a back part of the outer cylindrical part 80b to hold the covering member 80 in place as shown in Figs. 11 and 12.

[122]           As shown in Fig. 12, a large-diameter washer 89 is pressed against the upper surface of a front part of the outer cylindrical part 80b of the covering member 80 with a bolt 90 screwed through the washer 89 in a threaded hole 15p (Fig. 4) formed in the joining surface 19 of the gear case 15.

[123]           Since the front and the back part of the upper end wall of the outer cylindrical part 80b fitted in the top part 15d<sub>1</sub> of the shift rod receiving bore 15d are pressed down by the pump case 47 and the large-diameter washer 89, the covering member 80 can be securely held in place even if the pressure in the shift rod receiving bore 15d increases, any bolts and threaded holes are not necessary for holding the covering member 80 in place. Consequently, the number of necessary parts is small, part around the covering member 80 of the gear case can

be designed in a compact arrangement, and increase in the dimensions of the gear case can be avoided.

[124]           An upper end part 27a, to be connected to the upper shift rod 26, of the lower shift rod 27 projects upward from the inner cylindrical part 80a of the covering member 80 into the groove 83 between the bulged walls 81R and 81L.

[125]           The sealing member 85 seals the gap between the lower end of the upper end part 27a and the covering member 80. The exposed upper surface of the sealing member 85 is flush with the upper wall of the upper wall 80d, i.e., the bottom of the groove 83 of the covering member 80. Water that flows down along the upper shift rod 26 does not stay on the covering member 80 because the water is stopped by the sealing member 85 and is drained through the longitudinal groove 83.

[126]           When the lower shift rod 27 coupled with the upper shift rod 26 is turned, the shift fork 28 attached to the lower end of the lower shift rod 27 turns. Consequently, the front shift slider 65 and the back shift slider 66 are moved axially to set the forward/backward selector clutch mechanism 23 selectively in a forward drive position, a backward drive position or a neutral position.

[127]           Both the drive shaft receiving bore 15b and the shift rod receiving bore 15d connected to the drive shaft receiving bore 15b by the connecting hole 15i communicates with the gear chamber 15a. A threaded hole 15d<sub>2</sub> is formed in the gear case

15 so as to open into the shift rod receiving bore 15d at a level corresponding to the opening of the connecting hole 15i opening into the shift rod receiving bore 15d as shown in Fig. 11 to maintain the level of the lubricating oil contained in the gear case 15 at the level of the taper roller bearing 37.

[128]           The drive shaft receiving bore 15b communicates with the shift rod receiving bore 15d by means of the connecting hole 15i. When the internal combustion engine 11 operates to rotate the drive shaft 21, the oil-pumping member 36 pumps up the lubricating oil.

[129]           The lubricating oil pumped up by the oil-pumping member 36 lubricates the taper roller bearings 37, flows through a central hollow of the bearing fastening member 38, the space under the covering member 40 and the connecting hole 15i into the shift rod receiving bore 15d to lubricate the lower shift rod 27.

[130]           The respective open upper ends of the drive shaft receiving bore 15b and the shift rod receiving bore 15d are closed by the covering members 40 and 80, respectively, and the gear chamber 15 and the spaces communicating with the gear chamber 15 are sealed in a liquid-tight fashion to prevent the leakage of the lubricating oil from the gear case 15 and the leakage of water into the gear case 15.

[131]           The gear case 15 is designed such that the space in the gear case 15 including the gear chamber 15a has the least



necessary volume to build the outboard engine 10 in lightweight construction and to reduce the fluid resistance that acts on the outboard engine 10. The air chambers in upper parts of the drive shaft receiving bore 15b and the shift rod receiving bore 15d have limited volumes, respectively.

[132]           When the lubricating oil is caused to expand by heat generated by the bevel gear mechanism 22, air in the upper spaces in the gear case 15 is compressed to absorb the change of the volume of the lubricating oil. The pressure-compensating air chambers 82R and 82L of the covering member 80 are formed in a volume sufficient to contain air necessary for absorbing the change of the volume of the lubricating oil due to thermal expansion. Consequently, the increase of the pressure in the gear case 15 can be limited below the upper limit of an allowable pressure range.

[133]           The covering member 80 covering the open upper end of the shift rod receiving bore 15d receiving the lower shift rod 27 is provided with the bulged walls 81R and 81L defining the pressure-compensating air chambers 82R and 82L and formed in a dead space extending over the covering member 80. Thus, the covering member 80 has an additional pressure compensating function and the number of parts, assembling work and cost can be reduced.

[134]           Since any special holes connected to the gear chamber 15a are not necessary, the cost can be further reduced.

[135]           The covering member 80 is capable of supporting the lower shift rod 27 extending through the former. Thus, the covering member 80 has three functions, namely, a gear chamber covering function, a pressure compensating function and a lower shift rod supporting function.

[136]           The covering member 80 has compact construction; the inner cylindrical part 80a, supporting the lower shift rod 27, of the covering member 80 extends below the joining surface 19 of the gear case 15; and the bulged walls 81R and 81L defining the pressure-compensating air chambers 82R and 82L lie above the joining surface 19. The inner cylindrical part 80a supports the lower shift rod 27 securely.

[137]           The height of the space extending over the covering member 80 is limited by the forward extending wall 14a of the extension case 14. Therefore, the forward extending wall 14a of the extension case 14 is spaced a predetermined distance from a middle part 8a of the connecting member 8 to facilitate work for coupling the upper shift rod 26 and the lower shift rod 27.

[138]           The lower connecting member 8 serving as a component of a vibration-isolating outboard engine support structure can be positioned at a low level to achieve a desired vibration isolating function by positioning the forward extending wall 14a of the extension case 14 at a low level.

[139]           The upper walls of the bulged walls 81R and 81L declines

forward so as to conform to the shape of the forward extending wall 14a of the extension case 14 to increase the volumes of the pressure-compensating air chambers 82R and 82L to the largest possible extend in the limited space under the forward extending wall 14a of the extension case 14 at the low level.

[140]           The shift rod consists of the upper shift rod 26 and the lower shift rod 27, the lower shift rod 27 is extended through the covering member 80, and the upper end part 27a of the lower shift rod 27 projects upward from the covering member 80. Therefore, the gear case 15 and the components contained in the gear case can be easily assembled in a unit. Since the lower shift rod 27 turns about its axis and does not move vertically relative to the covering member 80, the gap between the lower shift rod 27 and the covering member 80 can be perfectly sealed.